Photoionization Using a VUV Free Electron Laser

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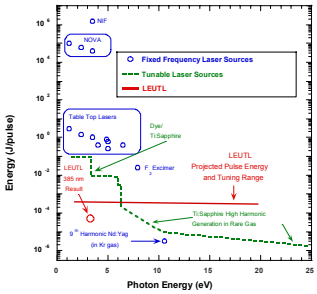
Motivation/Major Accomplishments

- A new high efficiency time of flight mass spectrometer has been constructed at the endstation of Advanced Light Source (APS) free electron laser (FEL)
  - Detect neutrals from ion sputtering and laser desorption
  - Efficient determination of surface atomic and molecular composition
  - Characterize the desorption process
- The APS FEL is first in U.S. to produce vacuum ultra violet (VUV) light
  - Tunable light down to 120 nm (10.3 eV)
  - Well suited for single photon ionization (SPI)
  - Many important elements and molecules that were previously inaccessible by photoionization can now be measured
- First measurements with instrument have been completed

Comparison of Laser Light Sources

- Few sources of VUV radiation
- Intensity and tunability needed for efficient photoionization
- ANL first in U.S. for VUV FEL

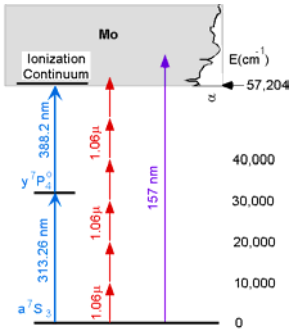


Low-Energy Undulator Test Line (LEUTL)

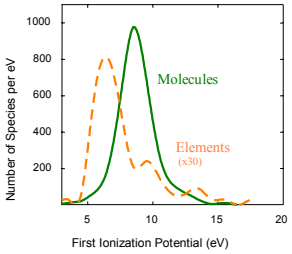
First VUV Light
September 9, 2001

Wavelength Tuning Range	600-120 nm
Photon Energy (E)	2-10 eV
Band Width (ΔE/E)	1%
Photon Energy Stability	±1%
Pulse Intensity	200 mJ
Intensity Stability	±20%
Pulse Width	≤0.3 ps
Repetition Rate	6 Hz

Single Photon Ionization (SPI)

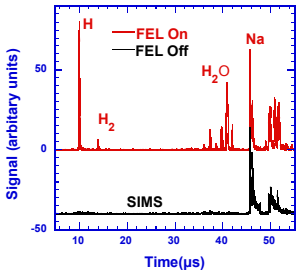


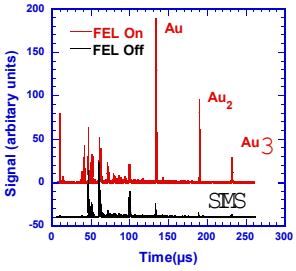
- SPI ionizes all neutral species simultaneously.
- VUV required for most elements
- ~1 μJ/mm² to saturate photoionization



Photoionization of Gold and Gold clusters

- Only secondary ions below the ionization potential (IP) of Au
  - FEL wavelength 127 nm (9.8 eV)
  - IP of Au equals 9.2 eV
- Light atoms and molecules are also observed
  - H peak may be due to fragmentation of molecules.





Impact and Future Directions

- Trace and surface analysis of high IP atoms and molecules possible
- Background discrimination by tuning above and below I.P. demonstrated
- Higher energy photons (15.5 eV; 80 nm) will be produced by the FEL will allow
  - Trace analyses of C, N and O
  - Photoionization of most organic molecules
  - Detection and imaging of biomolecules

Estimation of Useful Yield in Surface Analysis using Single Photon Ionization, King B. V., Pellin M. J., Moore J. F., Veryovkin I. V., Savina M. R., Tripa C. E., APPLIED SURFACE SCIENCE 203, 244-247 (2003)

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